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Poster: VALI – An SDN-based Management Framework for Public Wireless LANs

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ABSTRACT

Usage of WiFi is becoming increasingly popular in public wireless LAN (WLAN) settings like malls, airports and train stations. Similarly to other prominent examples of WiFi usage like enterprise and home settings, public WLANs could also benefit from an SDN-based coordinated management framework that deals with issues like interference and mobility management. However, unlike these settings, public WLANs present a few differences in their characteristics, such as the need to offer location-aware services and dynamic categorization of users, and the consequent need to provide sophisticated association strategies. Motivated by this we propose VALI , an SDN management framework tailored to meet the needs of public WLAN settings. We give an overview of VALI and present initial results obtained using our prototype implementation deployed over a testbed that resembles a realistic public WLAN environment. Our results demonstrate that VALI is a promising solution that could be used to effectively manage public WLAN settings and enable location-aware WiFi access.

CCS Concepts

•Networks → Programmable networks; Network management; Wireless local area networks;

Keywords

Public wireless LANs, SDN, management framework

1. INTRODUCTION

Usage of WiFi is widespread in public urban spaces including shopping malls, airports and train stations. Most of these deployments are operated and managed independently by non-cooperating retail stores or malls. However, the coordination among access points (APs) including those that are deployed by different entities can result in a wide range of benefits, such as seamless mobility, location-aware services, improved interference management and data offloading, leading to an improved user experience and network performance.

Currently, there exist several providers who offer WLAN deployment and management services in common areas of indoor public spaces like shopping centers (e.g. Inkspotwifi[1]). Such providers do not however offer management services for independently deployed WiFi hotspots within specific parts (e.g., coffee shops, book stores) of the same indoor public spaces, due to the lack of WLAN management frameworks that can enable coordinated operation of WiFi APs.

Moreover, the management of public WLANs poses certain unique requirements such as prioritized and location-aware differentiated services for users. For example, a dynamic way of categorizing mobile devices can help in eliminating the login process users need to undergo while visiting each shop or different areas of a mall. Furthermore, even though the intention of deploying an access point dedicated to premium users within a region of a public WLAN is to provide them an improved quality of service, this might not always lead to optimal results, with neighboring access points being able to offer improved services due to better RSSI or due to a better balance in the network load. Such concerns regarding the coverage and performance of public WLANs are also highlighted by recent studies [1]. We argue that by collaborative access and optimized user association in public WLANs, the network and per-user throughput as well as the overall user experience can be improved. Software-defined networking can naturally enable such features and therefore, by designing an SDN framework specifically tailored for public WLANs, several key concerns raised by public WLAN users could be addressed.

To the best of our knowledge there is currently no management framework targeting public WLAN settings using SDN or otherwise. In the industry, centralized WLAN management solutions target enterprise deployments (e.g., [2]), but are not designed to meet the unique requirements of public WLANs. Moreover, while SDN-based coordinated management of disparate WLANs is a promising approach, existing SDN-based WLAN management proposals in the literature target enterprise and home WLAN settings (e.g., [3], [4]).

With the above in mind, we aim at developing a solution that can deal with the public WLAN requirements for location-aware differentiated services and the dynamic role changes of users in a simple yet effective manner. Towards this end, we propose VALI [2], an SDN-based management framework tailored for public WLANs. The environment in which VALI is expected to operate is a public setting consisting of several WiFi APs deployed either by shop owners or by other management entities like for instance the central management of a mall and where shop owners would allow their APs to be managed by a central controller through the installation of an agent. Moreover, they would agree to give part of their wireless resources to be used by the controller for other purposes, e.g. for allowing access to guest users or to users of neighboring shops. The incentive for agreeing to participate in such a setting would be the overall improvement in the quality of experience of the public WLAN users

[1]https://inkspotwifi.co.uk/

[2]In Norse mythology, Vali is a son of the god Odin.

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(both shop customers and simple guests).

2. VALI SYSTEM OVERVIEW

VALI consists of a number of APs, each running an agent and communicating with the master controller (Fig 1). The management applications residing above it are responsible for maintaining a logically centralized view of the network and for managing the association of users to APs and the establishment of traffic rules according to the policies defined by the entities participating in the public WLAN. The agents of the APs are responsible for handling MAC operations, for gathering statistics and for enforcing the association decisions made by the controller.

VALI leverages the concept of a Lightweight Virtual Access Point (LVAP). For each client associating to the network a unique LVAP is created, providing an abstraction for user association by creating a unique BSSID. This allows the infrastructure to take control over user association and mobility management simply by performing a context transfer of the LVAPs from one AP to another. The idea of the LVAP was introduced by the Odin framework [3], however VALI extends it in order to deal with the new requirements of dynamic user prioritization and bandwidth allocation. To do this, the LVAP abstraction was extended to include an additional *tag* element, which describes the role of a client based on its current location and can be used by the controller for its association and prioritization operations.

Another key aspect of VALI are three management modules running as network applications on top of the controller (Fig 1):

Localization This module is used to dynamically differentiate and categorize users in the public WLAN setting. Using its location a client is tagged with a specific role. The role that a client assumes can change dynamically as the user roams the area of the public WLAN and is defined based on the agreement made between the AP owner and the management authority.

Optimized Association This module provides an association configuration in order to achieve a high overall network performance (in terms of throughput and fairness), considering parameters such as the network topology, the role of a user (user priority), the air time utilization of different QoS service classes and the amount of resources that the APs can provide for different types of users.

Prioritization This module is used to provide differentiated services to clients based on their current role. More specifically, the module observes the tag assigned to a client by the Localization module and imposes priority or bandwidth limitations on each AP.

The final components of VALI are an Environment (ENVI) server and a localization database. The database stores location-related information like WiFi fingerprints obtained during a training phase that are required to infer the user location, while the ENVI server stores the wireless environment of any user that is currently associated with the network and is used to decide whether the tagging of a client should change as the user roams the public WLAN area as well as whether a client should be associated with a new AP.

3. IMPLEMENTATION & INITIAL RESULTS

For our evaluation we built a prototype testbed managed by the VALI framework, consisting of three OpenWrt-based APs extended with support for the VALI agents and twelve heterogeneous clients (smartphones and tablets). The master controller and the management applications were deployed over the Floodlight controller with the Odin framework and the localization-enhanced LVAP abstraction enabled, along with the ENVI server and the localization database. Odin was also extended to support VALI specific messages.

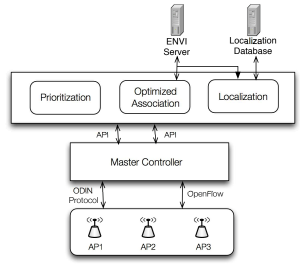

Figure 1: VALI System Architecture

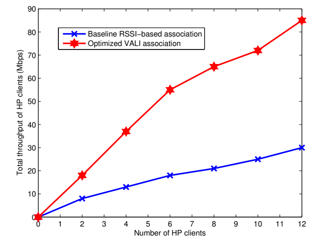

Figure 2: Optimized Association vs RSSI-based association

The testbed was deployed on the first floor of the Informatics Forum building at the University of Edinburgh, which is composed of a number of offices, labs and common spaces, resembling that of a real public WLAN deployment. We defined two types of zones for user access, a High Priority (HP) representing shop spaces and a Low Priority (LP) for common space areas, assigning each room of the region under study into one of these zones. Each AP was dedicated to a specific zone type with the majority of their resources assigned to serve users of that type. The remaining resources were available to be used by the controller for serving clients of the other type.

Based on this setting, we evaluated how the optimized association of VALI can offer a better utilization of resources, while taking into consideration the constraints of the client's expected type of service and the amount of resources that can be shared for different types of users. To achieve this we set two of the APs in LP zones and one AP in an HP zone and we set 20% of the resources of both types of APs to be shared with clients of other types. The idea of the experiment was to move devices from the LP zones to the HP zone and observe how this would affect the overall throughput of clients obtaining the HP service. As a baseline, we used an association scheme that allows the association of clients only to the AP with the highest RSSI with the constraint that this AP also belongs to the same zone as the client.

The client devices were initially placed in LP zones close to their common borders with the HP zone and generated TCP traffic using iperf. All the clients were initially forced to associate with the access points of LP zones similarly to how most mall guests would initiate their association with the network while entering the common areas of the mall. We would then move each one of the devices from the LP zone to the HP zone, making the VALI controller to dynamically switch their role from LP to HP devices. Our results (Fig. 2) show that as more devices switched from an LP to an HP zone the overall throughput of HP devices increased in both cases. Moreover, we can observe that the rate of increase in the baseline case is much lower than that of the optimized association case. The reason for this is that in the baseline case the controller chose to associate all HP clients to the HP AP, while in the case of the optimized association, some of the HP clients were associated with the LP APs even after they entered the HP zone, by exploiting the shared resources that the LP APs offered, leading to a higher total throughput. At the same time, the HP clients were still allowed to use the premium services offered by the HP zone even though they were associated to the LP APs.

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